Autonomous Operations

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The road to autonomous operations

Step-by-step from manual to autonomous

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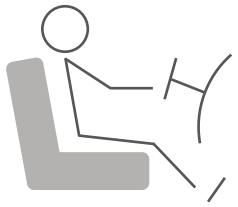
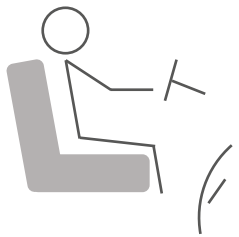
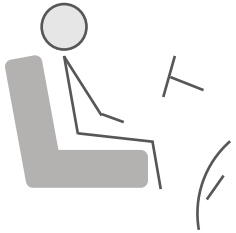
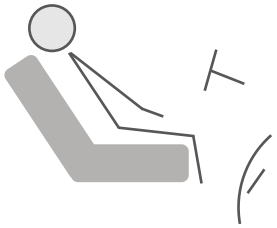
Step-by-step development of automation

Following the logic of the automotive industry, our roadmap is customized to fit specific airport needs

No assistance	Assisted	Partially Automated	Highly Automated	Fully Automated	Autonomous
					
Driver	Feet off	Hands off	Eyes off	Mind off	No driver

Human | **Transfer of Responsibility** | **Machine**

Illustration is based on the six levels of automation according SAE International (Society of Automotive Engineers).

Step-by-step development of automation

Aebi Schmidt's Airfield Pilot enables you to move forward step by step at your own pace

09 / 2020 — 10 / 2021 — 09 / 2022

Step 1: Driver Assistance System

- Driver navigation system applicable for all truck models and equipment brands (incl. competition)
- Suitable both for new machines and retrofit
- Route and TJS guidance incl. V2V communication

Step 2a: Automated TJS Control

- Automated steering of jet sweeper (plough, brush & blower) functionalities based on specific geo events
- System only applicable to Aebi Schmidt TJS

Step 2b: Supervised Automated Driving

- Automated truck +TJS/ jet sweeper control
- Driver remains in the cabin and keeps final responsibility for operation
- Currently system limited to Volvo carrier vehicles

Step 3: Autonomous Operations

- Core functionalities similar to supervised automated driving
- Due to driverless operation additional safety levels are required
- Liability is important

The road to autonomous operations

Where do we stand today?

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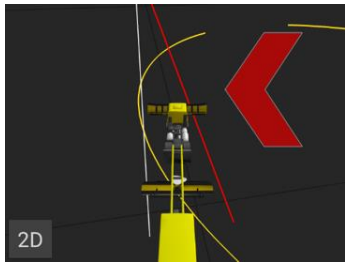
Airfield Pilot | Step 1 | Driver Assistance System for Jet Sweepers

Driver guidance offers many different supporting functionalities

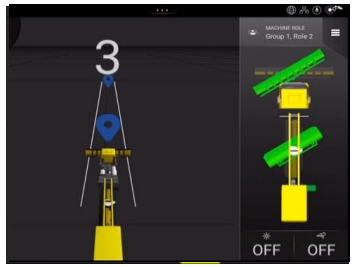
2D view of the area, outlines of the airport (yellow) are good to see

3D view of the operation area at **night mode**

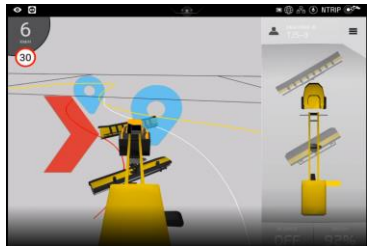
Driver is too much to the right; arrow **guides him** more to the left



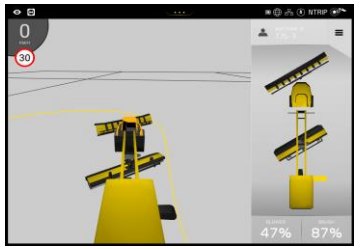
Countdown to Geo-Event and **future equipment position** shown in green



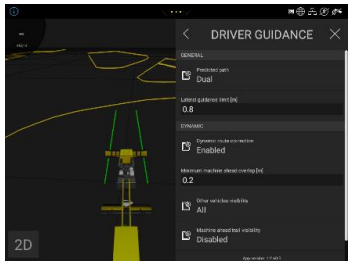
There are 2 **Geo-Events** to come (see blue markers)



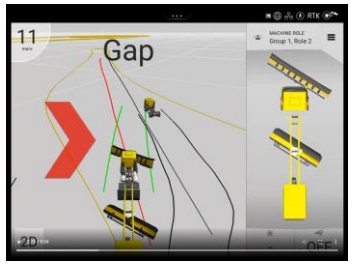
Day mode is activated; **Speed limit is set** for 30km/h



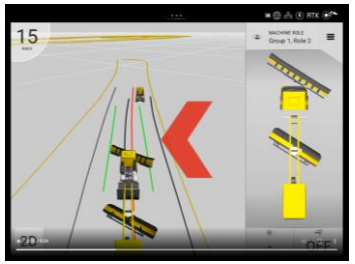
"Predicted path" functionality is **activated**, indicated by **two green lines.**



Dynamic route adjustment and deviation of the original route

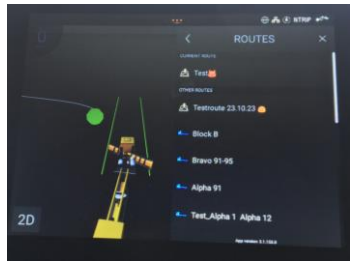


Efficient operation via highly precise route management in a fleet

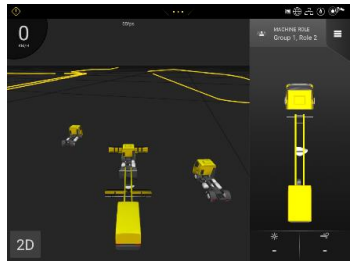


Recording a route for a fleet

Routes are **selected** either via the display in the machine or sent to the driver



Visibility of other machines is activated, all **other machines are shown**

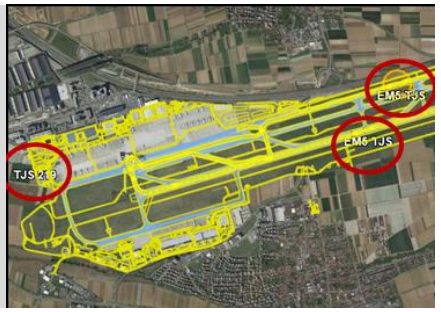


Airfield Pilot | Step 1 | Driver Assistance System for Jet Sweepers

Web-Editor (online tool)

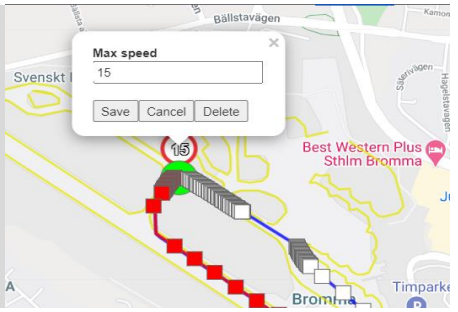
Real-time machine position

Web-Editor view to follow the machines in operation & flexibly adjust if required



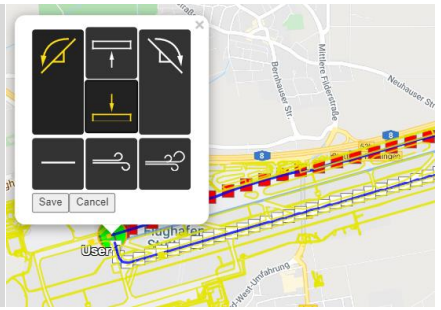
Create speed limits

In case fleet should stay to max. speeds, create limits



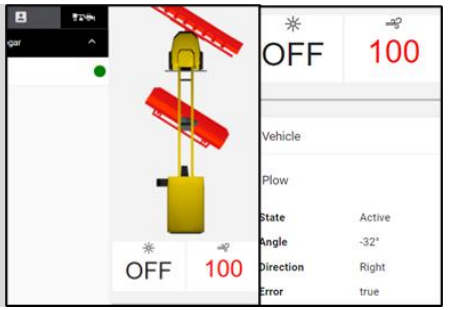
Geo-Events

Change Geo-Events (activity of plough, brush and blower) depending on needs



Vehicle status

Check if all machines are set to the correct working mode at Geo-Events

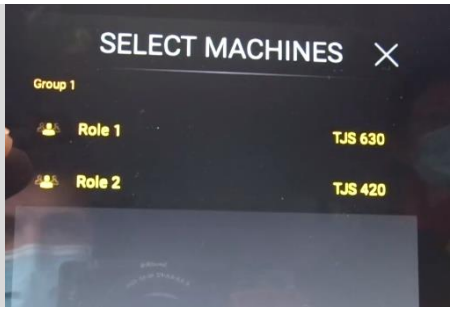


Edit routes

Adjust recorded routes, e. g. straighten them when needed, connect & implement tracks, etc.

Select machines

Machines can be deployed to routes / tasks as needed



Airfield Pilot | Driver Assistance System for Jet Sweepers

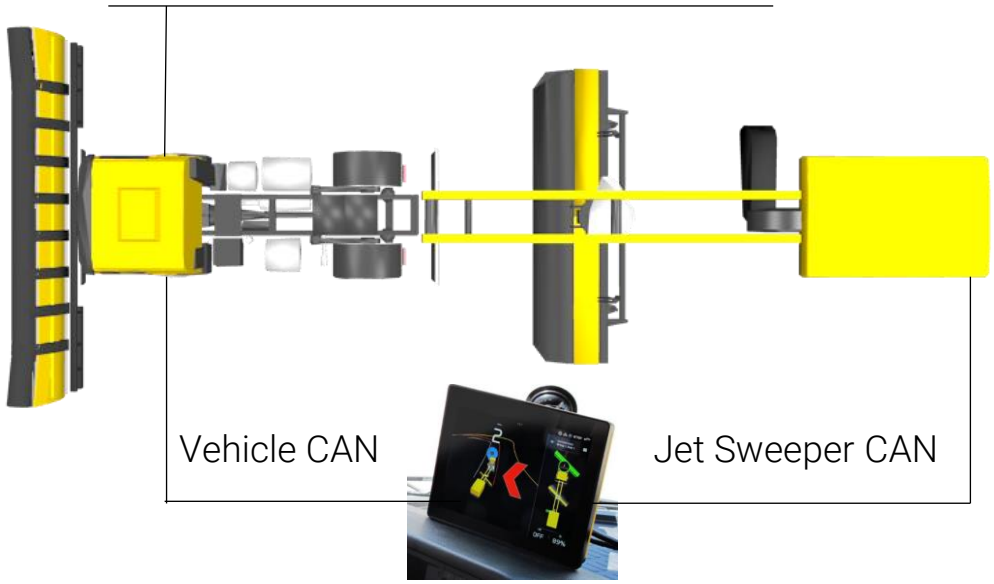
Wrap up of current system

Airfield Pilot | Step 2 | Supervised Automated Driving

System and component overview on a 5th wheel / king pin TJS (Towed Jet Sweeper) – Step 2

Technology for Supervised Automated Trucks

- LIDAR Sensors
- GPS
- Cameras
- Accelerometers and gyroscopes
- Radar
- ……



Aebi Schmidt Machine – Truck controller

Integrated Process Principle

- Aebi Schmidt Automation System Controller sends commands to truck and Jet Sweeper
- Truck and Jet Sweeper execute commands
- Safety systems of truck and Jet Sweeper take care of safety control
- Ongoing communication between truck and Jet Sweeper through Aebi Schmidt Automation System Controller

- **Developments** are in full cooperation with **truck manufacturers**

Development tests have been conducted all over Europe and in the US

Continuous Development is required to achieve an efficient system for optimum performance on airports

Numerous test and drive manouvers are performed in various different regions in Europe and the US

Valuable expert feedback has been implemented in the continuous design and development phases

Learnings

- Smooth interface between truck and jet sweeper
- Handling of airport map
- Flexible route management: CAD or online drawing tool
- Fleet operation & machine communication
- Machine size
- Flexible operation through lead driver
- Remote Tower & machine coordination
- Handling of airport operations
- From manual to automated process management

Driverless Automated Drive

Case study from Leipzig-Halle Airport

René Kirsten | Project Manager | Leipzig Airport

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The Airport Leipzig-Halle (Germany) at a glance

LEIPZIG·HALLE AIRPORT

General information

- Freight volume: 1.4 mio tons (2023) – second biggest cargo airport in Germany and fourth biggest in EU
- Passenger volume: 2.1 mio people (2023)
- Aircraft movements: 80 thousand
- Southern runway: 3600 x 60 m
- Northern runway: 3600 x 45 m (60 m incl. shoulders)
- Airplane positions: 25
- Area: approx. 14 mio m^2 (1400 hectare)

Winter maintenance

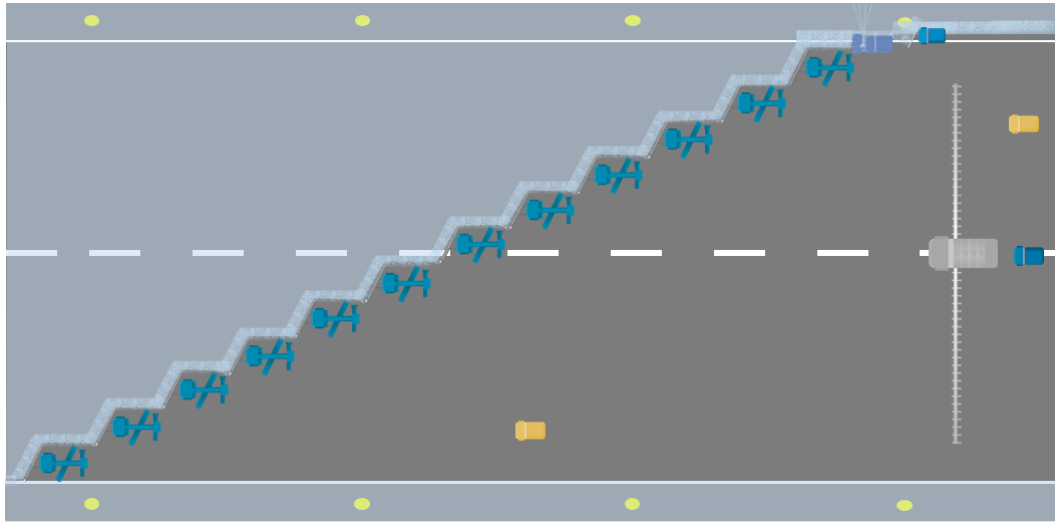
- Operational force: 300 (internal & external)
- Continuous three-shift operation
- Up to 80 personnel are available per shift
- All-weather flight operation type: CAT IIIb
- Average temperature in January: 4.1 °C
- Altitude of airport: 470 ft / 143 m above mean sea level

Project Input Airport Leipzig: Winter Operation

Current setup

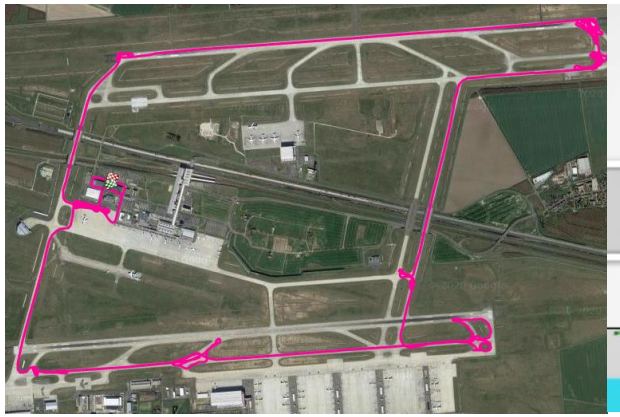
Standard Clearing Formation:

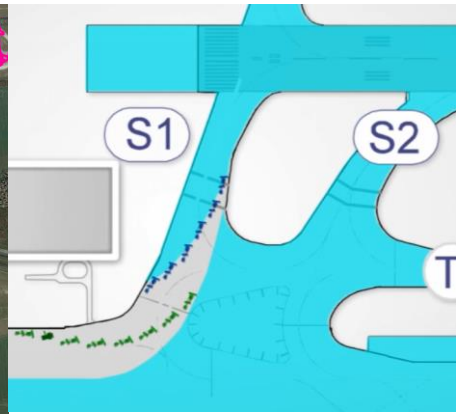
- 1 pass (line) clearing operation (all external drivers)
- 12 towed jet sweepers (TJS) / multifunctional units
- 2 airport sprayers
- 1 snow blower
- 1 tractor with snow plough
- ***Total: 16 units (2 groups, with 1 group only 1 sprayer)***



General Information:

- External drivers are recruited through European tenders
- Duration of the winter operation: 5 months, 24/7
- Alarm procedure starts 2 hours before the operation
- Intense driver training for min. 40 new staff prior to every season, mainly without truck driver´s licence
- Annual training procedure required: Background check, security training, airport driver´s licence, winter operation training, special TJS training





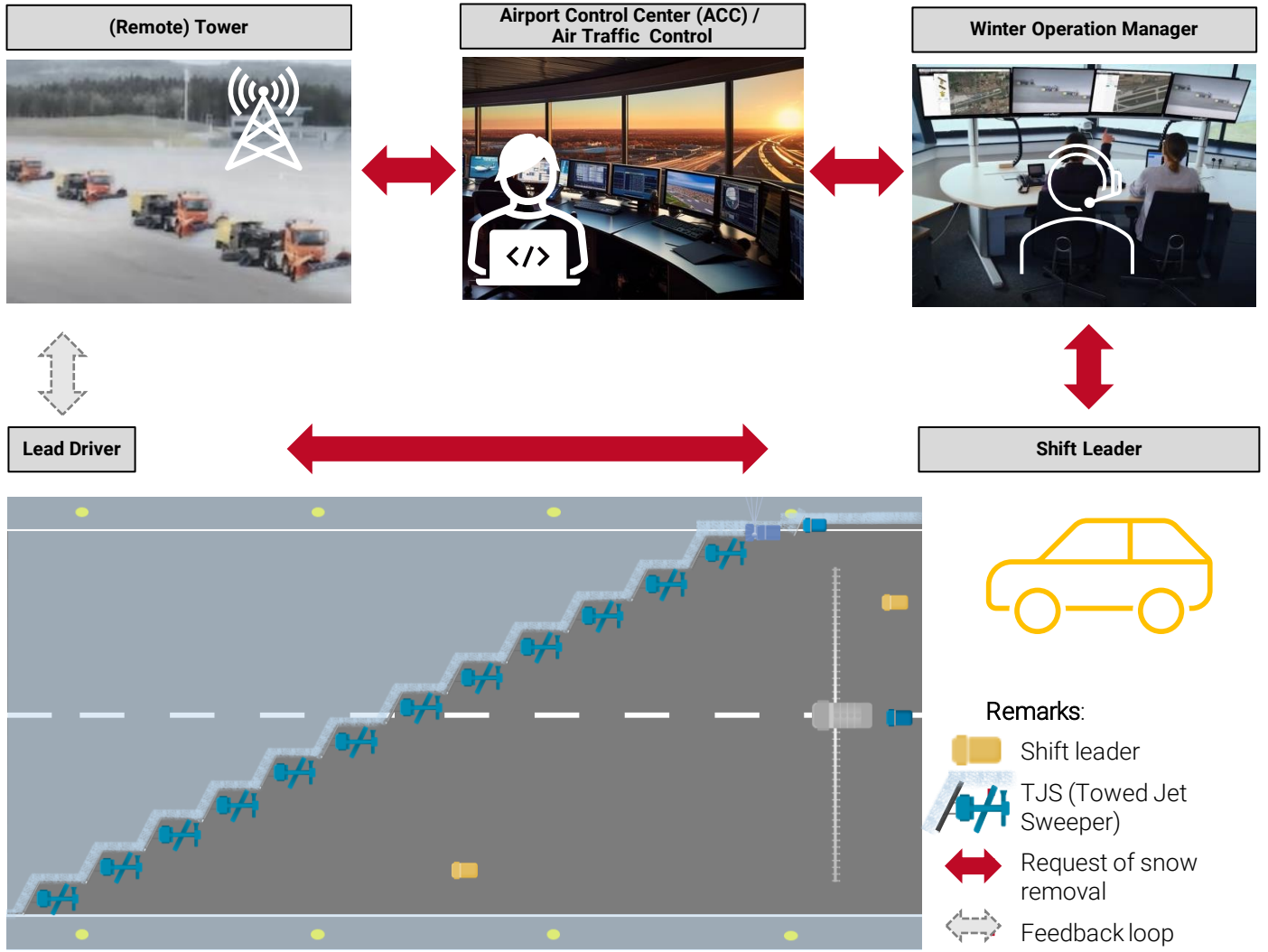
Project Input Airport Leipzig: Manual Clearing Procedure

Manual to be moved into autonomous operations

LEIPZIG·HALLE AIRPORT

Standard Clearing Process:

- Tower requests clean surfaces, especially priority 1 areas, such as runways + 1 taxiway
- **Comissioning Process:** Tower contacts ACC, ACC sends info to Winter Operation Manager, who informs shift leader. Finally, lead driver receives info.
- Once drivers are in the TJS they drive out the garage and prepare the machines (put plough in operational position on the apron and prepare brush pattern setting)
- There are 2 operational groups, which are together for runways, but split for taxiways :
  - 6 TJS per group
  - 1 airport sprayer per group
  - 1 lead driver per group (airport personnel, responsible for airport radio contact to tower)
- Once completed lead driver informs tower.



Project Input Airport Leipzig: Autonomous Operations

Challenges that are met during winter operation at Airport Leipzig

LEIPZIG·HALLE AIRPORT

Workforce

- Lack of qualified employees (currently 8 internal employees are responsible for 80 external)
- Difficult to recruit, due to social and demographic change as well as personal commitment
- Language barriers
- Extraordinary training effort for external staff (time and costs)

➔ **Staff shortage**

Weather

- Changing weather patterns
- Rather often false alarms due to black surface requirements
- Potential standby costs

➔ **Planning uncertainty**

Sustainability/Efficiency

- CO_2 reduction might be limited, but efficiency increase and better clearing performance expected through automated drive
- Extend life cycle of machines expected when working autonomously

➔ **CO_2 targets**

Profitability

- Training costs: Annual base rate per vehicle & season approx. 33 k €, hourly rate approx. 40,-€
- Less wear and spare parts
- Increased runway availability
- Service-level-Agreement with DHL: 1 runway + taxiway in max. 20 (completely)

➔ **Invest vs. running costs**

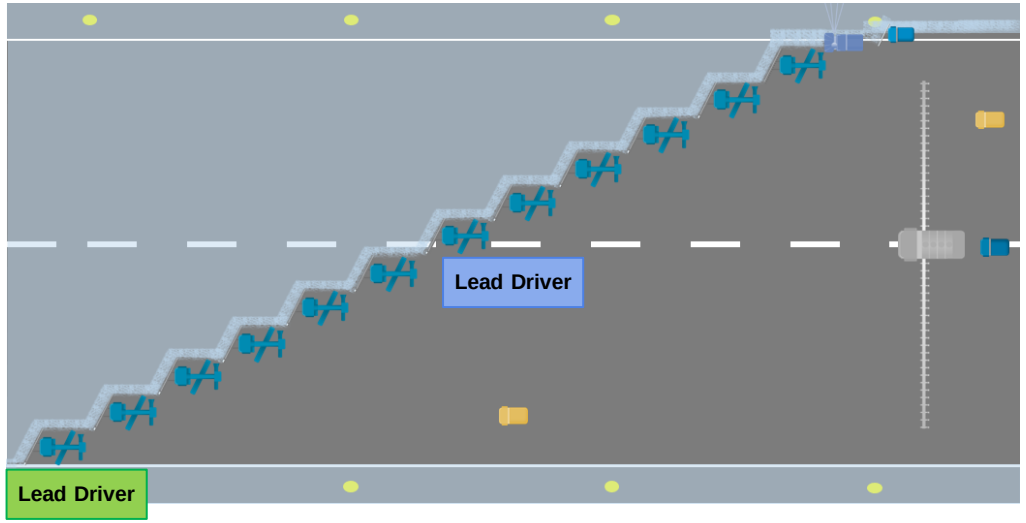
Project Input Airport Leipzig: Autonomous Operations

How does Airport Leipzig want to tackle the before mentioned challenges?

Project approach:

- To reach the next step in autonomous drive, a «herd principle» is required.
- Platooning / Herd Prinziple: 1 lead driver in first TJS, operating as “master“, 5 TJS to follow without driver as “slave“
- Route planning mainly conducted during “live“ operation.
  - The areas to be cleared are chosen from the PC
  - Correct order of routes on missions is chosen, which is to be the mission, e. g. following the operational plan on the airport (left, right, front, rear…)
  - Standard parameters during operation (amount of machines, clearing width, speed, overlap / distance between the machines, etc.), which will result in a complete operational procedure (missions per fleet / vehicle)
- Driver in the “master“ machine communicates with tower via airport radio and receives clearance for complete fleet

Potential Procedure during operation



Open Question

How to deal with refuelling the machines, moving in / out of the garage as a fleet?

Driverless Automated Drive

The Herd Principle: A solution to Leipzig’s challenge

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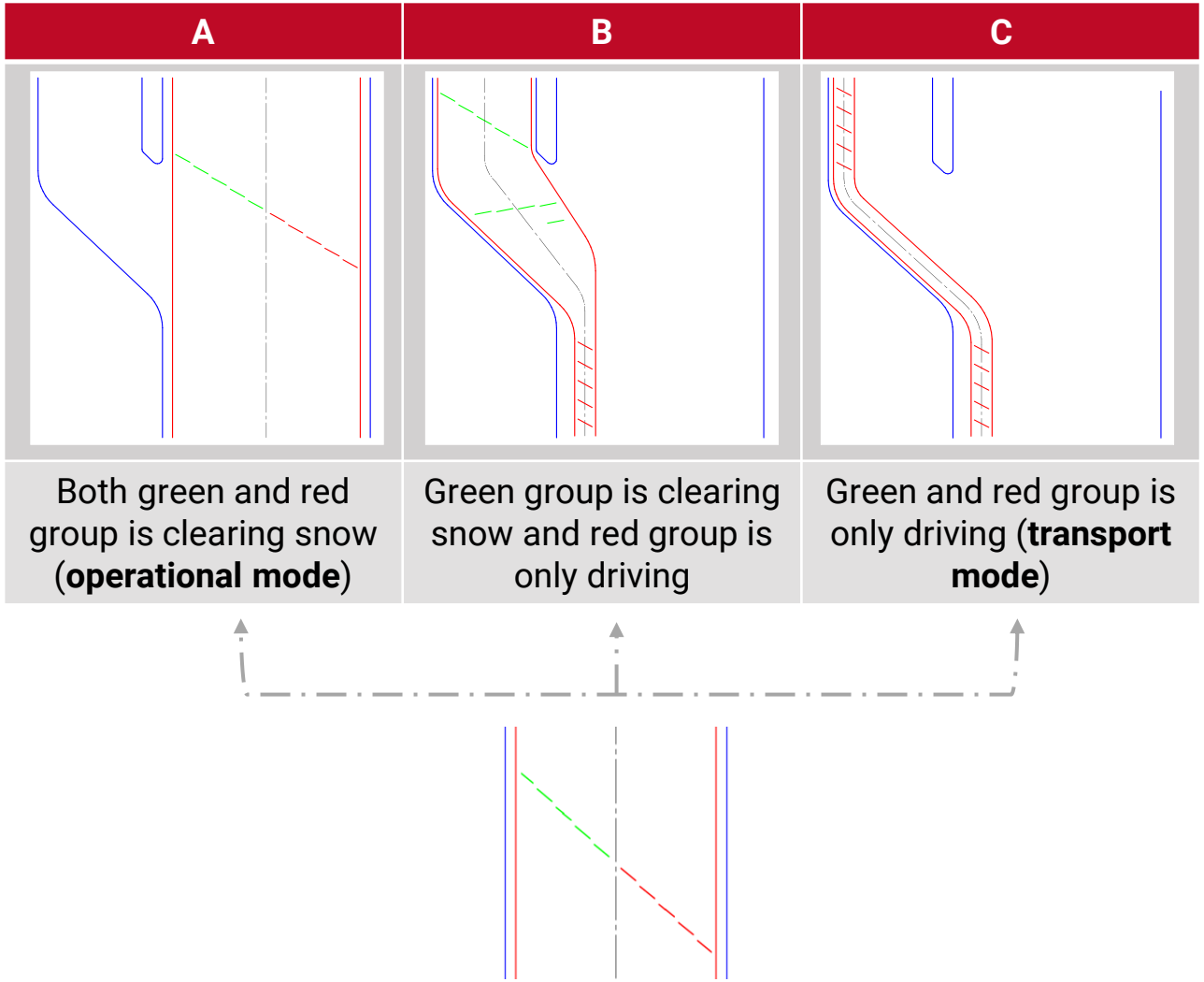
The Herd Principle: Operational Process

Description

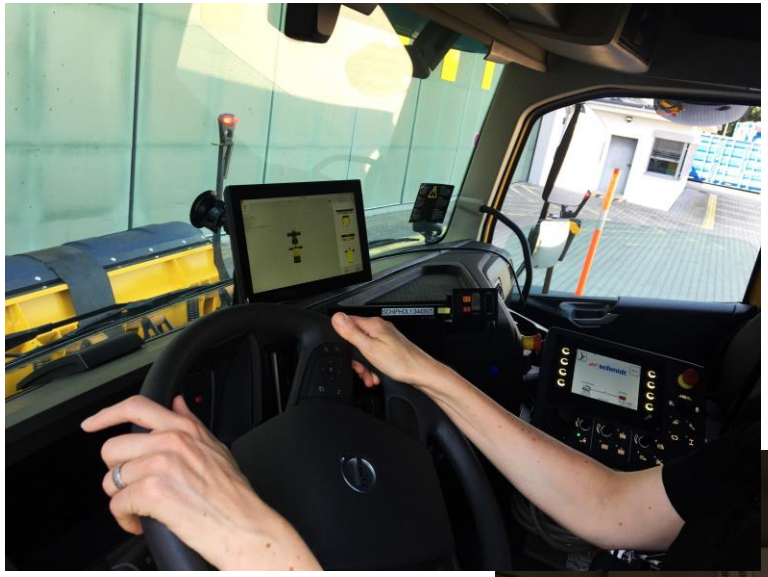
- **Routes can be flexibly connected into missions**.
- The vehicles will have individual, predefined routes to ensure that the area is cleared from snow.
- **The heard can be managed by operator** (lead driver in the first vehicle per group) or from a remote tower or winter operation manager in a vehicle.
- The lead driver can change the mission during operation by choosing different sections / routes.
- **During operation** a mission can be changed flexibly by choosing new sections or routes or missions.
- Sections are defined by recording outer edges or import from CAD data.
- The route for each vehicle in a section is defined in a pre-processing offline tool.
- Default missions are defined by combining a set of sections / routes.
- Distance control to ensure that the heard is intact.

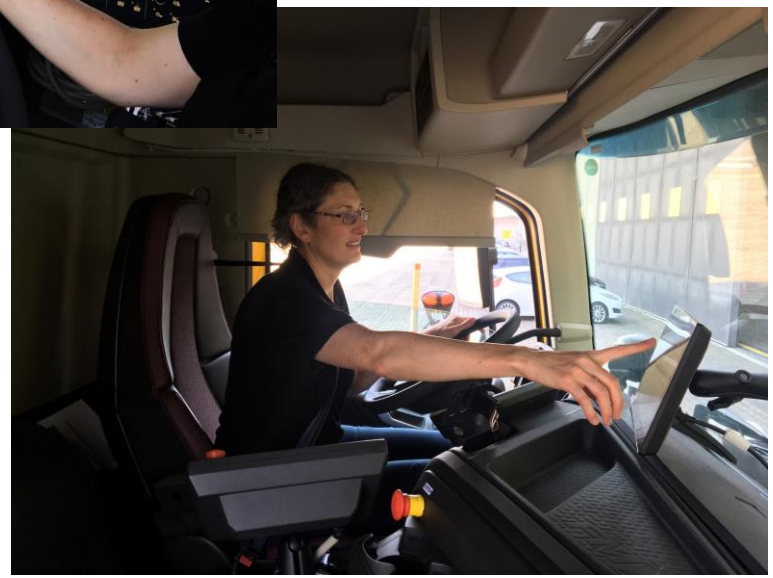


The Herd Principle: Hardware Updates

Process Development

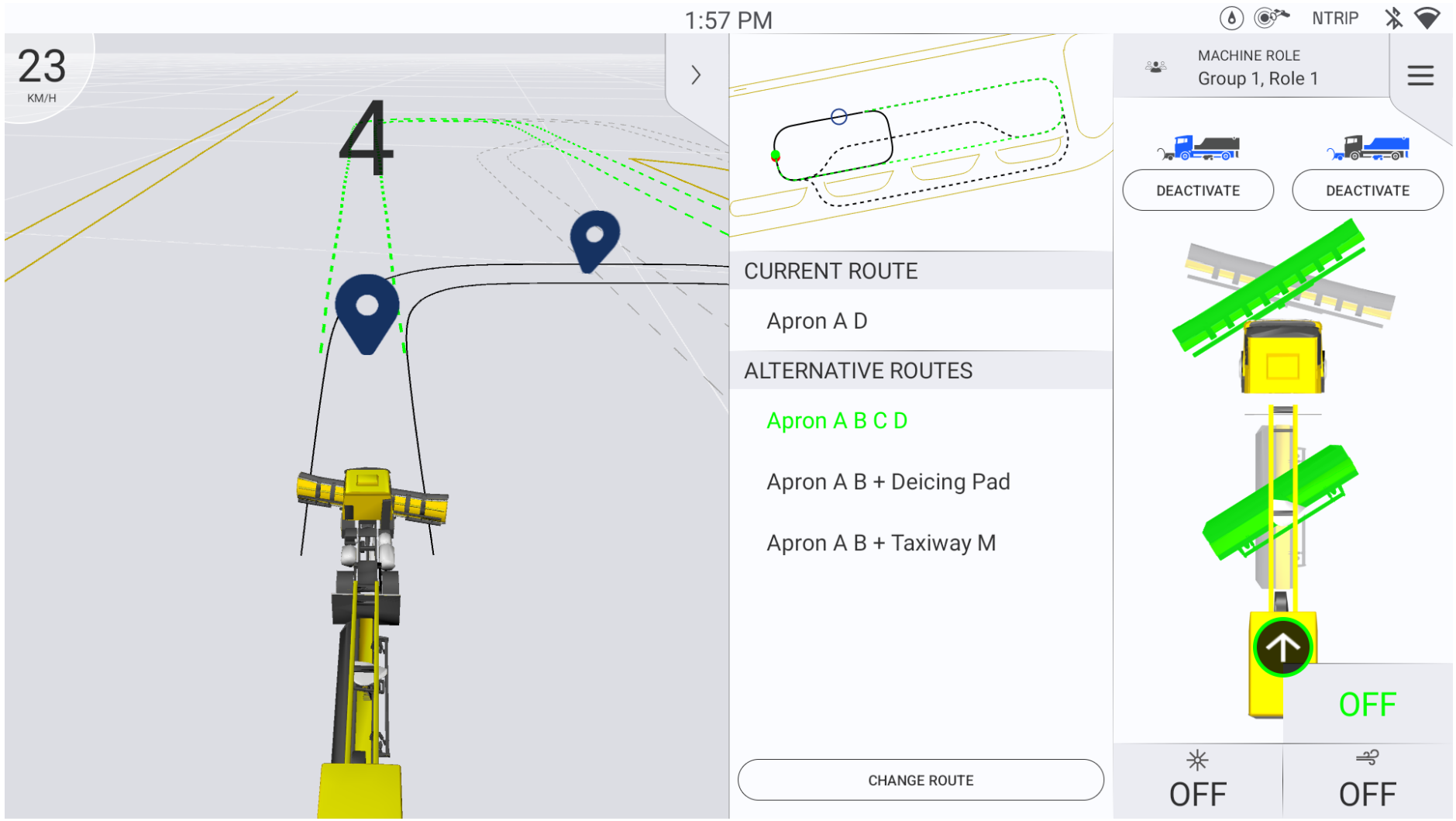
- Continuous updates based on field tests & customer feedback
- Transfer to new hardware system
- New screen and new processor to increase processing power to optimize response time





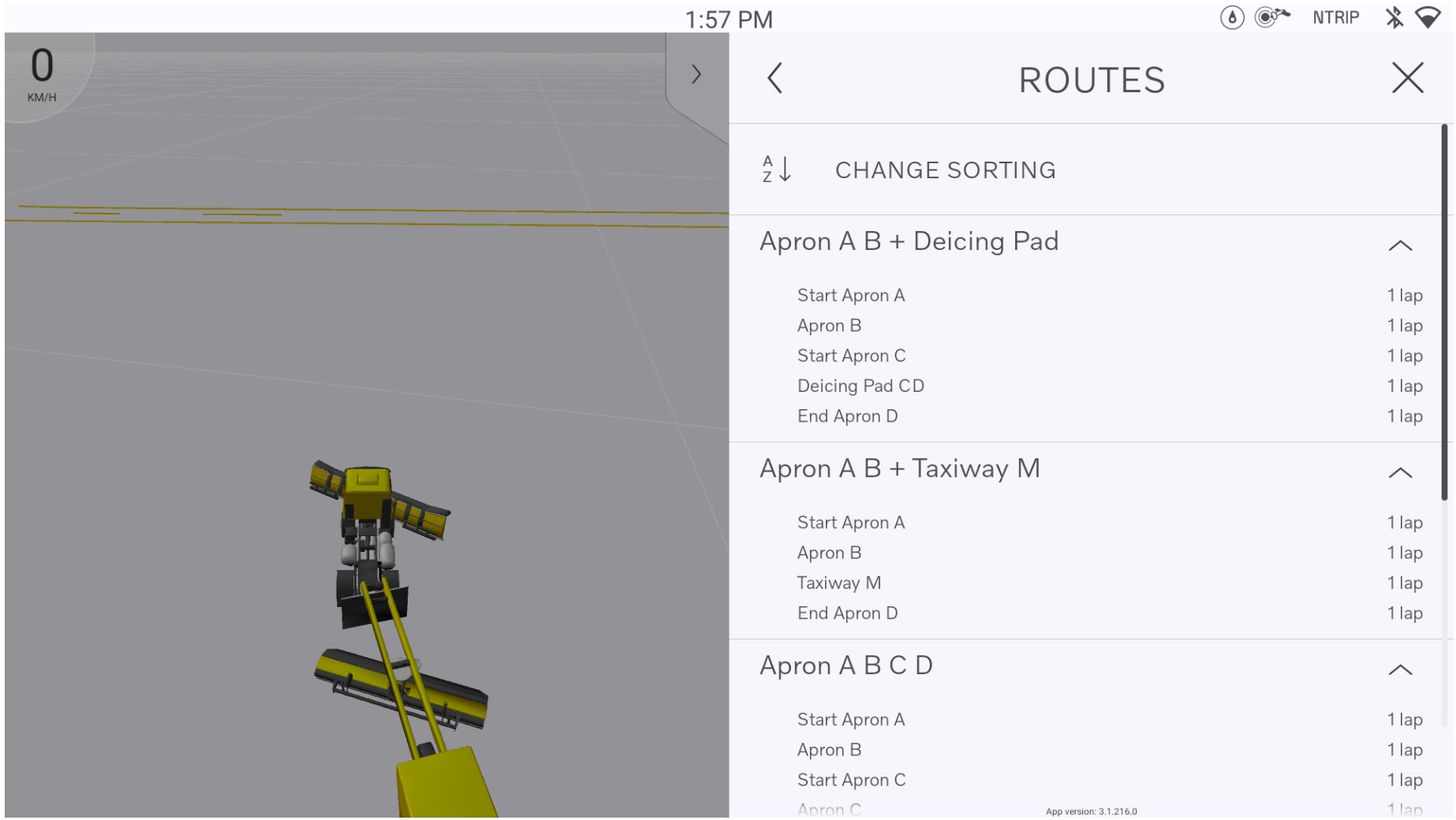
The Herd Principle: Software Updates

Examples



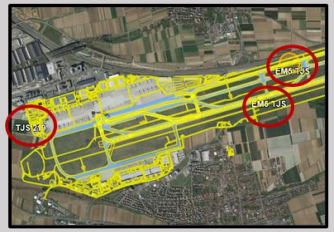
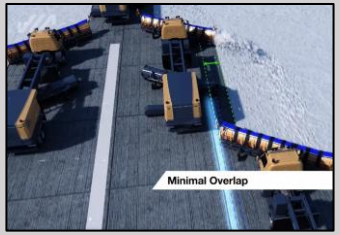
The Herd Principle: Software Updates

Examples



Summary

Automated and autonomous operations offer many benefits

Excellent Overview	Minimal overlap between machines	Reduced training effort	Increased efficiency	Reduce costs	Flexibility increase
					
▪ Web-Editor view ▪ Easy overview of machine operation & tasks deployed	▪ Saves time ▪ Optimized length of fleet & working width	▪ Driver quickly learns what to do ▪ Optimized performance quality	▪ Maximum runway availability ▪ Less CO_2 (fuel) consumption	▪ Less damage to machines & infrastructure ▪ Extended life cycle of machines	▪ Flexibly change routes during operation ▪ React to changing weather quickly

Automated and autonomous systems lead to:

- **substantial performance improvement**
- **consistent operation performance quality level**
- **cost savings**
- **increased flexibility**
- **greater levels of safety**

Please share your feedback and experience with us …

… because to achieve an efficient system for optimum performance on airports, an open dialogue and continuous development is crucial for success.

Meet and talk to us during the breaks, at the dinner, on the demo fields or reach out to us anytime for an appointment.

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Thank you for your time and interest!